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SOME CITY WATER-SUPPLIES.

BY E. H. S. BAILEY AND EDWARD BARTOW.

THERE are practically five sources of supply for cities in the Missouri valley, viz.: (1) Rivers; (2) points or wells sunk into the soil near the bank or in the belt of the river; (3) wells; (4) artesian wells, or those that are bored to great depth; (5) ponds or lakes.

Local conditions in each case must determine which shall be the source of supply, but it often happens that from a financial standpoint one source of supply would be selected, while from the standpoint of wholesomeness of water an entirely different water would be used. Rivers are liable to be contaminated from the sewerage of towns, or from the barn-yards, stock pens or hog wallows on their banks; and the same remark applies to ponds and lakes. The water of a well may or may not be pure, according as the well is or is not properly situated with reference to drainage, sewerage, and other sources of filth.

In Kansas and vicinity a large number of cities draw their water-supply from wells, because that is the only feasible source. There are in Kansas the following river systems where the water is abundant enough to be used as a source of public supply, viz.: (1) Missouri, (2) Kaw, (3) Marais des Cygnes, (4) Neosho, (5) Verdigris, and (6) Arkansas. On these streams are situated the largest cities and villages, and so on these streams and their larger tributaries are most of the plants for supplying water to the public.

Some years ago a thorough analysis was made of the water of the Kaw valley system, during the winter stage, and this

report was published in the *University Quarterly*.[1] A series of analyses of the Kaw river at Lawrence has also been made, and a report on the analyses of the water, made during several months of the year 1903, will appear in the Division of Hydrography, United States Geological Survey. During the last year we have made some analyses of the waters of the Neosho river system. There are quite a number of cities on the upper waters of this stream that are dependent on small creeks running into the Neosho for their supply. We refer especially to Florence, Peabody, Marion, Council Grove, White City, and Cottonwood Falls. Beginning with Emporia, the following cities are dependent on the Neosho river directly for their water, viz.: Burlington, Iola, Chanute, Parsons, and Oswego. Analyses of Burlington and Iola water were made some time ago. The source of the Parsons water is a small stream and pond tributary to the Neosho. The following towns, situated on or near the Neosho river, are not yet supplied by public water-works: Le Roy, Neosho Falls, Yates Center, Humboldt, Erie, and Chetopa. We have taken up especially the water-supply of Chanute, Oswego, and Chetopa.

THE NEOSHO RIVER SYSTEM.

The city of Chanute is one of the largest of those that draw their public water-supply from the Neosho river. On May 1 of this year one of us[2] visited this city for the purpose of getting samples of the water for analysis. The water-works, which are owned by the city, are about one and a half miles east of the city, on the west bank of the river. Worthington pumps are used to pump the water from the river to the settling-basins during the night, and to force it into the city mains during the day. Although the pump-house is well above the river bank, the pumps are down nearly to the river level, so as to avoid suction as much as possible.

There are two settling-basins, which are said to have a capacity of 2,500,000 gallons each. These basins are lined with cement, and are connected through a gallery filled with gravel and sand. The material in the filter is, however, not often changed. The basins are cleaned about once a year, or when-

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[1] *Kansas University Quarterly*, vol. III, pp. 1-12.
University Science Bulletin, vol. I, pp. 99-111.

[2] ailey.

ever the mud has accumulated sufficiently. At the time the sample was taken the water in the river was only slightly above medium height, and was clearer than usual for that time of the year, as it had not been rendered turbid by recent rains.

The capacity of the pump is 1,000,000 gallons per day, but it is not running up to its maximum. The river is usually much higher in the latter part of May and in June, but gets to the worst and lowest stage in August or September. At the latter date it does not flow rapidly and is covered with a green scum, indicating vegetable growth. When the water is at its flood stage, the river carries a large amount of silt, dead animals, trees and all sorts of floating rubbish. A stream runs into the river some distance north of the city, which in high water is liable to bring considerable contamination to the water, as there are slaughter-houses upon its banks.

During the flood stage of the Neosho, the water covers the bottoms and is up around the pump-house, but it has not covered the basins for some years. The city water is not very extensively used for drinking purposes, as many of the people still use wells and cisterns. There were some cases of typhoid fever, but there are not sufficient data to tell whether they are in families using city water or not. The city has a sewer system, which it is rapidly extending. The outlet is into the river, at a point below the water-works. The pipes of the water company are also being extended rapidly into the outlying parts of the city, to accommodate the increasing population.

The analysis which is given below, from what has been said, evidently represents the water when in a good condition, better than the average. A sample was taken from the river opposite the pumping station, from the second settling-basin, and from the city mains in Doctor Lardner's office.

SANITARY ANALYSIS OF CHANUTE WATER-SUPPLY.

Parts per million.	Neosho river.	Settling-basin.	Service pipe.
Total solids	414.8	412	457
Loss on ignition	48.	12.8	12.5
Chlorin	9.07	9.21	8.50
Free ammonia	.011	.034	.052
Albuminoid ammonia	.199	.332	.351
Nitrogen in nitrates	.979	.960	.946
Nitrogen in nitrites	.000	.000	.000
Oxygen consumed	2.58	3.00	2.27
Hardness	207.7	201.2	202.5

From the analysis the following conclusions are drawn:

1. The amount of total solids, which means the mineral matter left on the evaporation of the water, is not large, as compared with some of the other streams of the state. The Kaw river above Lawrence is often 760, as compared with 414 in the Neosho. The constituents of this mineral matter will be considered later.

2. The chlorin, which usually represents the amount of salt in the water, is low in the Neosho, as in the drainage basin there are no alkali plains or salt marshes.

3. The free ammonia, which is regarded largely as an index of the animal matter in the water, is not high in any sample. It is, however, not as good in the sample taken from the pipes as in the untreated river water. This would indicate that, on account of the large amount of organic matter in the water, a partial decomposition takes place in the pipes, under some conditions, so that more free ammonia is generated. The sample taken from the pipes was not as clear as that taken from the river.

4. The amount of albuminoid ammonia is large; in fact, it is too high for a good water. Here, also, the river water was better than that in the pipes. It is probable that this varies with the time allowed for settling and the frequency with which the pipes are flushed out. This part of the analysis shows that the amount of organic matter, particularly that of vegetable origin, is too great. Much of this could be removed by treatment with a coagulant and subsequent filtration, as in the case of the Oswego water, which is noticed elsewhere, and which is also taken from the Neosho river.

5. The amount of nitrogen as nitrates is not excessive, and represents the results of oxidation of organic matter in the soil and in the flowing stream.

From all the data obtained, then, it is evident that the water-supply is not very satisfactory, even at this stage of the river. A more definite opinion of the water can be given when its composition at the lowest stage and at the flood stage also is known.

The last town in the state having a public water-supply from the Neosho river is Oswego, the county-seat of Labette county. The water plant is owned by a private company, and is situ-

ated on the border of the city park, in a wooded ravine, above the high-water line, northeast of the city. The Neosho at this point runs nearly east, and the banks are well wooded and high.

The water is drawn from the river by a fourteen-inch pipe, and then forced into the city mains through Jackson filters, sometimes after being treated with a little alum to act as a coagulant. The amount of alum used depends on the turbidity of the water. The sand in the filters is cleaned by reversing the current of the water as often as the pressure shows that this is necessary. About 250,000 gallons is pumped in twenty-four hours, although the capacity of the plant is four times that amount.

As the population of the city is not very large, and so many of the citizens use the water of wells and cisterns, the demand upon the water company is not very great. The experience of the company in regard to purification of the water is, that any amount of coagulant will not clarify the water at certain stages of turbidity.

Three samples of water were taken; the first from the pipe that draws the water from the river, the second from the pipe as it conveys the water to the city, and the third from the service pipe in Kingman's drug store.

SANITARY ANALYSIS OF OSWEGO WATER-SUPPLY.

Sample taken May 2, 1903.

Parts per million.	Neosho river.	Filtered water.	Service pipe.
Total solids	430	320.4	312.8
Loss on ignition	18	20.7	15.1
Chlorin	7.23	6.80	7.08
Free ammonia	.098	.030	.020
Albuminoid ammonia	.418	.234	.184
Nitrogen in nitrates	.415	.881	.314
Nitrogen in nitrites	.000	.000	.000
Oxygen consumed	5.67	3.12	2.90
Hardness	164.4	165.8	163.1

A consideration of these analyses shows the following:

1. The total solids or mineral matter is reduced twenty-seven per cent. by the process of filtration. If alum is not used, it is practically the suspended matter which is taken out. It will be noticed that the amount of total solids is not very different from that at Chanute, more than fifty miles further up the stream.

2. The amount of chlorin or consequently of common salt is small, a little less than at Chanute, which may be due to dilution with pure waters.

3. The free ammonia, though rather high in the unfiltered water, is very materially diminished by filtration, and thus the water is improved.

4. The albuminoid ammonia, which is excessive in the original water, is very much diminished in the sample supplied to the city, showing that much of the vegetable or organic matter has been removed.

Considering the whole analysis, then, it is evident that the water is greatly improved by this kind of filtration, and the water that is furnished is of fair quality. There is no doubt that when the water is at its flood stage, without further treatment, it would be difficult to furnish a water that is entirely satisfactory.

NEOSHO RIVER AT CHETOPA.

Chetopa is situated on the right bank of the Neosho, at a point where there is a sharp curve towards the east. Beyond the city the river runs for six or eight miles before it flows out of the state. As at other points along the river, the difference in the height of the water produces a great difference in its quality and in the rate of flow. During the flood season the river has been twenty-five feet higher than under ordinary conditions.

There is no public water service here, but water is pumped from the river to a tank in the city to use for sprinkling purposes.

As this is the last town of any size in the state on the river, the analysis of the water was made, for comparison with others farther up the stream.

SANITARY ANALYSIS OF THE NEOSHO RIVER AT CHETOPA.

Sample taken May 2, 1903.	Parts per million.
Total solids	390.4
Loss on ignition	18.9
Chlorin	7.60
Free ammonia	.060
Albuminoid ammonia	.363
Nitrogen in nitrates	1.021
Nitrogen in nitrites	.000
Oxygen consumed	3.82
Hardness	176.2

The analysis shows that the untreated water is better at Chetopa than at Oswego. This may be partly due to dilution of the water by Labette creek, and partly to sedimentation and oxidation.

In order to more fully understand the water of the Neosho system, a mineral analysis was made by Mr. C. F. Gustafsen of a sample taken in Doctor Lardner's office in Chanute. The following is the result:

Grams per liter.

IONS.		RADICALS.	
Calcium (Ca.)	.0756	Calcium oxid (CaO)	.1058
Magnesium (Mg)	.0004	Magnesium oxid (MgO)	.0007
Chlorin (Cl)	.0085	Ferric oxid (Fe_2O_3) / Aluminum oxid (Al_2O_3)	.0294
Sulfuric acid ion (SO_4)	.0491	Chlorin (Cl)	.0085
Silicic acid ion (SiO_2)	.0796	Sulfuric anhydrid (SO_3)	.0409
		Silicic anhydrid (SiO_2)	.0796

The above constituents may be hypothetically combined as follows:

	Grams per liter.	Grains per gallon.
Sodium chlorid ($NaCl$)	.0140	.818
Sodium sulfate (Na_2SO_4)	.0577	3.370
Calcium bicarbonate ($CaH_2(CO_3)_2$)	.1783	10.414
Calcium sulfate ($CaSO_4$)	.0144	.841
Magnesium bicarbonate ($MgH_2(CO_3)_2$)	.0015	.088
Oxids of iron and alumina	.0294	1.717
Silica (SiO_2)	.0796	4.649
Totals	.3749	21.897

This analysis shows the water to be of excellent quality, as far as the mineral matter is concerned. The total solid matter (21.897 grains per gallon) is not as high as that found in many of the other rivers of the state. On this account, then, the water is well adapted to domestic and boiler use. The chief mineral substance present in the water is calcium carbonate, and that can be readily removed by treatment with a little milk of lime or by the use of washing soda.